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(54) **INKJET AIRBRUSH SYSTEM**

(75) Inventor: **Blair M. Kent**, Vancouver, WA (US)

(73) Assignee: **Hewlett-Packard Company**, Palo Alto, CA (US)

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(51) **Int. Cl.**[7] **B41J 2/015**; B41J 3/00
(52) **U.S. Cl.** **347/21**; 347/2
(58) **Field of Search** 347/21, 20, 25, 347/2

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,709,926 A		4/1929	Weaver	
4,019,188 A	*	4/1977	Hochberg et al.	346/75
4,508,271 A		4/1985	Gress	
4,546,922 A		10/1985	Thometz	
4,723,712 A		2/1988	Egli et al.	
5,086,978 A		2/1992	Fertig	
5,298,967 A	*	3/1994	Wells	356/336
5,852,075 A	*	12/1998	Held	523/161

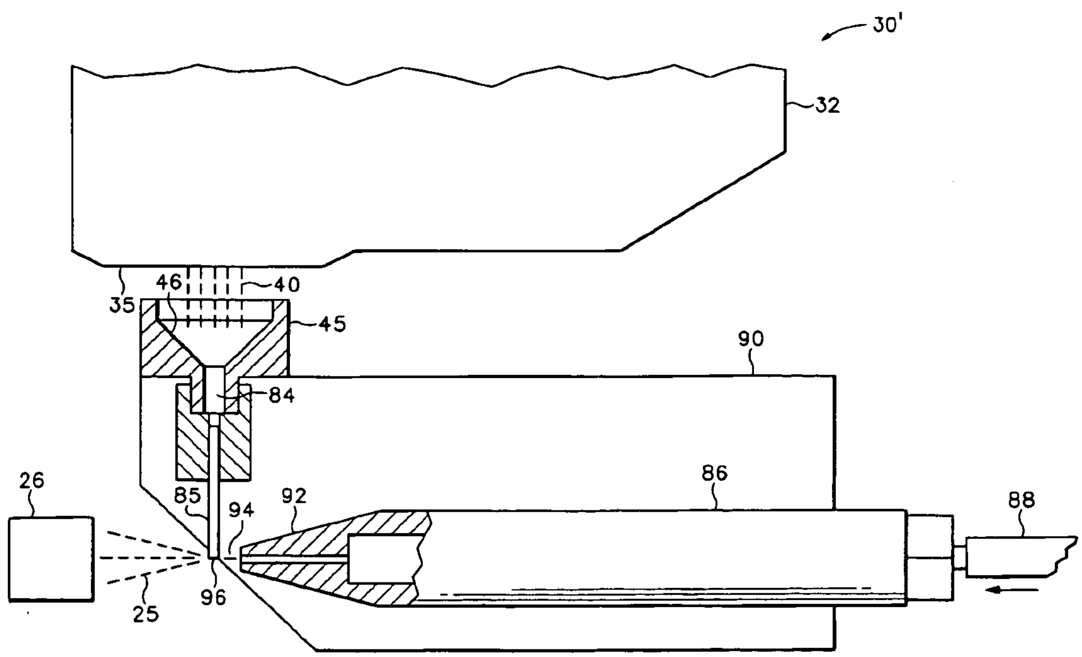
* cited by examiner

Primary Examiner—Thinh Nguyen
(74) *Attorney, Agent, or Firm*—Flory L. Martin

(57) **ABSTRACT**

An inkjet airbrush system uses inkjet printing technology in a new manner for color mixing in airbrush painting. A variety of different configurations are used to generate atomized custom colors which are blown by the inkjet airbrush onto an object. In response to firing signals, a printhead ejects a custom blend of colors which are combined in a mixing chamber and then atomized using any type of atomizer desired. The firing signals may be generated by a remote device, such as a computer, or they may be generated on-board the inkjet airbrush in response to a user input, such as a code selected from a color chart. The amount of colorant passing through the airbrush may be varied by varying the firing signal frequency. The inkjet airbrush provides fast color changes and faster clean-up than conventional systems. A method of applying a fluid on an object is also provided.

70 Claims, 2 Drawing Sheets



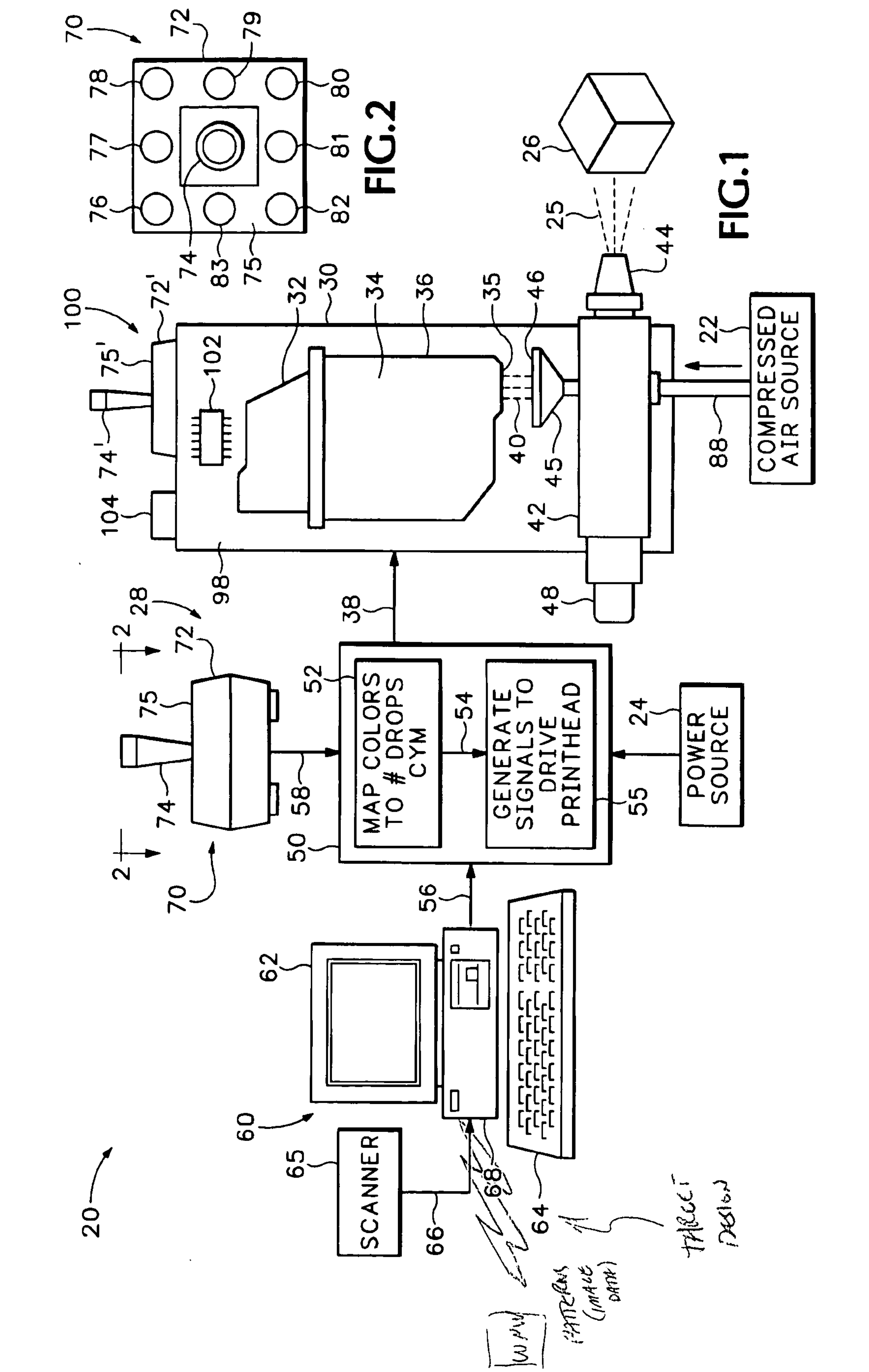

MAP COLORS TO # DROPS CYM
GENERATE SIGNALS TO DRIVE PRINTHEAD
POWER SOURCE
COMPRESSED AIR SOURCE
SCANNER

FIG.1

FIG.2

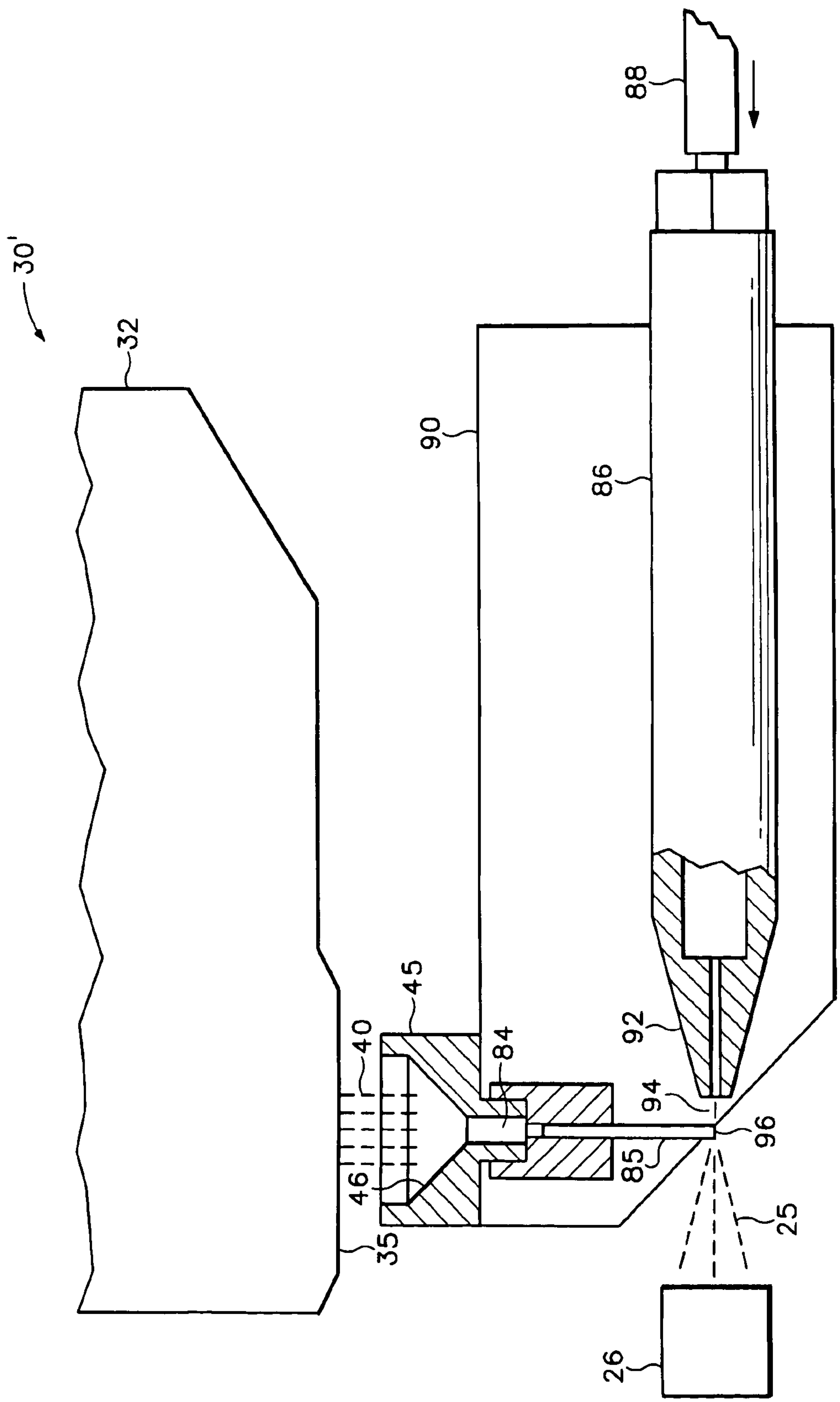


FIG.3

INKJET AIRBRUSH SYSTEM

This description relates generally to inkjet printing technology which is used in a new nonconventional environment, here for color mixing in airbrush painting. Here we are dealing with a marriage of two, previously distinct technologies, which now yields several new patentable concepts. Before delving into a detailed description of these new concepts, a brief discussion of conventional inkjet technology may be helpful, along with some of the difficulties encountered with conventional airbrush technology.

Conventional inkjet printing mechanisms use cartridges, often called "pens," which shoot drops of liquid colorant, referred to generally herein as "ink," onto a page. Each cartridge has a printhead formed with very small nozzles through which the ink drops are fired. Most often, the printhead is held in a carriage that slides back and forth along a guide rod in a "reciprocating printhead" system, with the page being advanced in steps between each pass of the printhead. To print an image on paper media, for instance, the printhead is propelled back and forth across the page, shooting drops of ink in a desired pattern as it moves. Other printing systems, known as "page-wide array" printers, extend the printhead across the entire page in a stationary location and print as the media advances under the printhead. The particular ink ejection mechanism within either type of printhead may take on a variety of different forms known to those skilled in the art, such as those using piezo-electric or thermal printhead technology.

For instance, two earlier thermal ink ejection mechanisms are shown in U.S. Pat. Nos. 5,278,584 and 4,683,481, both assigned to the present assignee, the Hewlett-Packard Company. In a thermal system, a barrier layer containing ink channels and vaporization chambers is located between a nozzle orifice plate and a substrate layer. This substrate layer typically contains linear arrays of heater elements, such as resistors, which are energized to heat ink within the vaporization chambers. Upon heating, an ink droplet is ejected from a nozzle associated with the energized resistor. By selectively energizing the resistors as the printhead moves across the page, the ink is expelled in a pattern on the print media to form a desired image (e.g., picture, chart or text).

Colors typically dispensed by the cartridges are black, cyan, yellow and magenta, with the resulting image color being obtained by mixing these four colors when the ink droplets impact the page. Recently, an imaging cartridge system has been introduced by the Hewlett-Packard Company of Palo Alto, Calif., as the DeskJet® 693C model inkjet printer. This is a two-pen printer which uses a tri-color cartridge, carrying full dye-loads of cyan, magenta and yellow, and a black cartridge which may be replaced with a tri-color imaging cartridge. This imaging cartridge carries reduced dye-load concentrations of some colors, such as cyan and magenta, along with a full or partial dye-load concentration of black ink. The imaging cartridge allows the printer to produce more continuous tone changes, particularly flesh tones, so the resulting image has near-photographic quality, with very little graininess. In the same vein, inkjet cartridges may be produced to carry custom colors, such as specialized tones having trademark notarization.

Turning now to airbrush technology, there are a variety of different styles and types of conventional airbrushes sold at most typical hobby stores. These handheld airbrushes are used for painting models, crafts, fingernails, pictures, automobiles, motorcycles, T-shirts, etc. A variety of different paint compositions may be used in these airbrushes, such as

lacquers, inks, watercolors, thinned solvent-based enamels, airbrush acrylics, and the like. Typical airbrushes use compressed air to draw the fluid from a reservoir into a nozzle where the fluid is atomized and propelled onto a surface to create an image.

For projects requiring multiple colors, the conventional airbrush painter has several options as to how to proceed. One way to apply multiple colors is to prepare each color separately, spray it on the image, and then clean the airbrush before moving on to apply the next color. Unfortunately, the process of switching from one color to another is time consuming and messy, because the airbrush must be completely cleaned between colors. Indeed, mixing, trying and tuning in the colors is time consuming and costly in terms of wasted ink while trying to obtain the desired color mix. Another option for applying multiple colors is for the painter to use multiple airbrushes each carrying a single color. Unfortunately this option has its drawbacks, too, due to the added cost of purchasing multiple airbrushes, and because each of these airbrushes now must be cleaned at the completion of the paint job. A further drawback of these earlier systems is that the finished image is limited to having only the exact color and hue of the paint which is loaded in the airbrush.

One goal herein is to provide a new inkjet airbrush system and method which expands the concepts of inkjet printing to other uses, such as for painting artwork and other images on items like canvas, sculptures, murals, models, vehicles, etc.

DRAWING FIGURES

FIG. **1** is a partially schematic diagram of one form of an inkjet airbrush system using an internal atomizer, along with several different operator input systems.

FIG. **2** is a top plan view of one form of an operator input mechanism, taken along lines **2**—**2** of FIG. **1**.

FIG. **3** is an enlarged, partially fragmented, front elevational view of an alternate inkjet airbrush system having an external atomizer, which may be used in the system of FIG. **1**.

DETAILED DESCRIPTION

FIG. **1** illustrates one form of an inkjet airbrush system **20** constructed in accordance with the present invention. The system **20** receives an input of compressed air from a compressed air source **22**, and electrical power from a power source **24**, which are used to generate fluid droplets **25** to be sprayed onto an object, here shown as a cube or box **26**. While compressed air is used for the illustrated embodiment, other similar propellants may be substituted for the air source **22**. The system **20** includes an operator input and controller section **28**, which receives inputs from an operator and generates control signals to power an inkjet airbrush portion **30** of the system. The inkjet airbrush **30** includes a fluid dispensing cartridge **32** which is based on inkjet technology to store one, but preferably two or more different types of fluid within a reservoir portion **34**. The cartridge **32** also includes a printhead **35**, which may be constructed using any type of known inkjet technology, such as thermal fluid ejection technology or piezo-electric fluid ejection technology. The cartridge **32** also includes a flex circuit **36**, which is used as an electrical/mechanical interface to allow the cartridge **32** to receive firing signals **38** from the controller section **28**. Upon receiving firing signals **38**, the inkjet printhead **35** operates to dispense unmixed fluid **40** from the reservoir portion **34**.

A variety of different inkjet cartridges may be substituted for the cartridge 32 illustrated in FIG. 1. The illustrated cartridge 32 represents the cartridge which was used in prototype testing, here the Hewlett-Packard Company's tri-color inkjet cartridge, part no. HP51525A, which has three reservoirs holding cyan, magenta, and yellow inkjet inks. The unmixed fluid 40 in FIG. 1 may be one, two or all three of these colors, depending upon the firing signals 38 which are received. The same technology used in the inkjet arts to deliver firing signals 38 and ink to printhead 35 may be used, including those used in reciprocating printhead printing systems, whether known as "on-axis" systems which carry all of their ink supply back and forth along the scanning axis, or those using "off-axis" technology where the main ink reservoir is stored at a remote location and ink is delivered to the reciprocating printheads via tubing or other fluidic conduits. Indeed, even page wide array printhead technology may be used, where a sheet of paper passes under a single stationary printhead which extends across the entire printzone. Thus, a variety of different inkjet printing technologies may be used to supply the unmixed fluid 40 in response to receiving firing signals 38, with the exact method used depending upon the particular implementation employed.

The inkjet airbrush 30 also includes an atomizer member 42, which has a nozzle portion 44 that ejects the fluidic droplets 25. The inkjet airbrush 30 also has a mixing member, such as mixing cup 45 which is used to couple the cartridge 32 with the atomizer 42. The illustrated mixing cup 45 has an interior surface which defines a mixing chamber 46 therein, to receive the unmixed fluid 40 ejected from printhead 35. Mixing may also occur as the ink 40 travels toward the mixing cup, as well as through the atomizer 42 and perhaps, even as droplets emerge from the nozzle and impinge on object 26. The illustrated atomizer 42 is an internal atomizer, which includes a fluid control section 48 that meters the amount of fluid delivered from the mixing cup 45 to the nozzle 44. Before discussing operation of the atomizer 42, along with several alternative embodiments for the atomizer 42, a description of the operator input and control section 28 will be given first. In the illustrated embodiment of FIG. 1, the atomizer nozzle 44 shown is representative of the prototype atomizer studied, which uses an Aztek nozzle manufactured by the Testor Corporation, of Rockford, Ill., although a nozzle with a shorter flow path is preferred for faster color changes.

The inkjet airbrush system 20 includes a droplet generation controller 50, which forms a portion of the controller section 28. The generation controller 50 has a mapping section 52 that supplies a droplet signal 54 to a firing signal generation section 55, which generates the firing signals 38 in response to input signals, such as signals 56 and 58 which are supplied to the controller 50. The mapping section 52 receives input signals 56, 58 requesting a desired color, and the mapping section 52 determines how many droplets of cyan (C), yellow (Y), and/or magenta (M) are required to generate the desired color, such as according to technology used in the inkjet arts to print images on media, e.g. paper. This information is carried via the drop signal 54 to the firing signal generator 55. The signal generator 55 may be a sophisticated device, choosing between which nozzles of the inkjet printhead 35 to fire based on various parameters known in the inkjet art, such as by alternating nozzles to provide more uniform heat dissipation throughout the printhead in thermal inkjet technologies. With the mixing cup 45 located directly under the printhead 35, it no longer becomes important which droplet from a given nozzle is fired, an

important factor in printing technologies where selection of which nozzle to fire determines where the drop lands on the resulting image. For example, in the illustrated embodiment, the nozzles of the printhead 35 may be fired at frequencies of 0–3000 Hz (Hertz). The intensity of the ink applied to the object 26 may be varied by varying the number of nozzles fired in an array or by varying the firing frequency of all nozzles to dispense different amounts of ink for mixing in cup 45.

One illustrated operator input in the controller section 28 is a computer input section, such as a personal computer 60 which may be used to select the desired color inputs delivered via signal 56 to the droplet generation controller 50. A variety of different means may be used to generate the input signal 56. For instance, the computer 60 may include a touch screen monitor 62 which may be used to display a color pallet, with an operator touching the screen 62 at the location of the desired color to generate the input signal 56. Alternatively, the computer 60 may have a keyboard 64, a mouse or a touch pad input device (not shown) to select a color displayed upon monitor 62. Other inputs may be supplied to the computer 60, such as by using a scanner 65 which generates an input signal 66 representative of a pre-existing image placed in the scanner 65. Upon receiving the input signal 66 from the scanner 65, the computer 60 may be used to alter or edit the scanned image, prior to generating the input signal 56. It is apparent that other equivalent input mechanisms may be used to supply image data to the computer 60, for instance, by using a modem or web-based interface to download images from the world-wide web or internet, as well as reading images from conventional storage media, such as floppy diskettes or CD ROM disks. Indeed, if the motion of the inkjet airbrush nozzle 44 is known, if the movement of object 26 is known, or if the relative movement between the nozzle 44 and 26 is known and controllable, for instance using robotic technology, then the computer 60 may send swaths of color data to the droplet generation controller 50 to create the desired image on object 26.

In addition to, or instead of the computer 60, the inkjet airbrush system 20 may include a manual color input selection device 70, here illustrated as a "joystick" input device having a base 72 and a toggling input handle 74. The manual input device 70 includes a faceplate 75 which surrounds the handle 74. As mentioned above, the joystick handle 74 may toggle in any direction, from 0–360° in the view of FIG. 2. The faceplate 75 includes a plurality of color indicia surrounding handle 74, here illustrated as color spots 76, 77, 78, 79, 80, 81, 82 and 83. In the illustrated prototype embodiment, the colors assigned to each of the indicia 76–83 were selected as shown in Table 1 below.

TABLE 1

Joystick Face Plate Colors
(100% is for all nozzles of a given color fired at 3 KHz)

Item Numbers	Color	% Cyan	% Magenta	% Yellow
76	Blue Green	100.	0.	26.6667
77	Yellow Green	26.6667	0.	100.
78	Yellow	0.	0.	100.
79	Yellow Orange	0.	100.	100.
80	Magenta	0.	100.	0.
81	Red Violet	26.6667	100.	0.
82	Blue Violet	100.	26.6667	0.
83	Blue	100.	0.	0.

While a series of color spots 76–83 are illustrated in FIG. 2, it is apparent that in some embodiments it may be

desirable to have a continuous, rainbow-like color pattern surrounding the joystick handle **74**, with the various colors gently blending into one another. Indeed, this rainbow selection was the effect achieved using the joystick **74** when selecting between two color spots, such as between adjacent spots **81** and **82**, or between opposing spots **81** and **77**. The type of joystick device **70** used may vary, with a simple analog potentiometer type of unit being used during prototype testing, allowing a rainbow of colors to be mixed using the inkjet airbrush **30**. The intensity of each color applied to object **26** may be varied by the spacing between the nozzle **44** and the object **26**, with closer spacings applying more ink per unit area to the object for a darker image, and larger spacings yielding lighter colors with less saturation of ink. Using some of the newer digital joysticks or similar input devices as selection device **70**, not only the color mixture, but also the intensity may be easily and separately controlled, allowing for a full, three-plane or three-dimensional color signal **58** to be supplied to the droplet generation controller **50**.

Furthermore, after achieving the desired color, the intensity may be separately varied by adjusting the firing frequency of the printhead nozzles, assuming the spacing between the spray nozzle **44** and the object **26** remains relatively constant. By controlling the firing frequency, the color intensity per unit area on object **26** may be more precisely electronically controlled, an option unavailable with conventional airbrushes. Thus, by supplying three color plane data to the droplet generation controller **50**, a constant spacing may be maintained between the inkjet airbrush nozzle **44** and the object **26** receiving the droplets **25**, with more droplets being delivered for increased intensity of color, and fewer droplets being supplied for lighter shades. For those unfamiliar with inkjet printing technology, it should be noted that while the cartridge **32** may also contain a fourth chamber for dispensing black ink, this is not a requirement because the combination of roughly equal amounts of cyan, yellow and magenta ink together combine to form a black color, known in the art as "process black," as opposed to a "true black" which would be dispensed from a separate reservoir containing only black ink. Thus, use of the tri-color (cyan, yellow, magenta) cartridge allows application of all colors on the object **26**, including black.

Turning now to FIG. **3**, instead of using the internal atomizer **42** shown in FIG. **1**, an alternate inkjet airbrush **30'** may be formed using the fluid dispensing cartridge **32** and the mixing cup **45** as described above. The mixing chamber **46** is receives unmixed ink **40** dispensed by printhead **35**. The mixing chamber **46** has a conically shaped cup surface, formed as a funnel with an outlet **84** to which is coupled a fluid transport tube **85**. Compressed air may be delivered by the compressed air source **22**, as described above, via an airflow tubing or conduit **86** and **88** to drive an external atomizer **90**. The compressed air from source **22** is supplied to an atomizing nozzle **92**, which together with the fluid conduit **86** forms the external atomizer **90**. The external atomizer nozzle **92** is positioned to blast pressurized air **94** past an outlet **96** of the fluid conduit **85**. As the air blast **94** flows past the conduit outlet **96**, through a venturi effect this rushing air draws ink out of the mixing cup **45**, and in this process causes the liquid ink to be atomized forming droplets **25** to paint object **26**. Actually, the force of the pressurized air **94** passing by the conduit exit **96** reduces the pressure in this region, creating a vacuum force. This vacuum force created by the air **94** blowing from nozzle **92** serves to pull the ink from cup **45**, with the exposure of the fluid to this vast moving air stream causing the fluid to atomize to create droplets **25**.

Thus, in a broad sense the concepts disclosed herein deal with the precise metering and measuring of a single liquid, or the precise metering, measuring and mixing of two or more liquids to form a desired precise liquid compound using inkjet technology. Indeed, the inkjet cartridge **32** may be used for the precise metering of a single fluid. For instance, using the internal atomizer **42**, flow through nozzle **44** of the fluid is generally controlled using the fluid flow control **48**, which operates to move an internal needle either into or out of the path of ink flow to restrict or enhance the flow. The flow control provided by the needle adjust **48** may be eliminated in the inkjet airbrush context, where the amount of fluid flowing through nozzle **44** may be controlled by metering and measuring the amount of unmixed fluid **40** entering cup **45**. Thus, a precise electronic metering of fluid by the printhead **35** replaces the crude mechanical fluid flow controls of earlier conventional airbrushes.

Another drawback of conventional airbrushes was the extensive clean-up time required. Using the inkjet airbrush system **20**, clean-up is much easier because the ink is self-contained within the fluid dispensing cartridge **32**. Moreover, by using one of the reservoir chambers **34** as an ink solvent reservoir, the airbrush **30** may be actually self-cleaning by ejecting the solvent from printhead **35** to clean the mixing cup **45** the internal portions of atomizer **42**, and nozzle **44**. For the external atomizer **90** of FIG. **3**, such an ink solvent or other fluid solvent dispensed by the printhead **35** may be used to clean the inside of mixing cup **45**, the exit port **84** and conduit **85**, along with the exit opening **96**. Indeed, one clean-up improvement was realized by minimizing the volume or space between printhead **35** and the atomizer nozzle **44**, **96** which is installed within a body **98**, illustrated schematically in FIG. **1**.

The exact form of the body **98** depends upon ease of use and ergonomic considerations, along with the type of cartridge **32** and the type of atomizer **42**, **90** which are used. Functionally, the body **98** provides an electrical connection via flex circuit **36** to receive firing signals generated by the operator input and controller section **28** of the system **20**. Additionally, the body **98** serves to locate the printhead orifice plate **35** over an ink mixing region, such as mixing cup **45**, in the broadest sense to precisely meter one or more fluids dispensed by cartridge **32**. In a more detailed example in the context of an airbrush, the body **98** also serves to couple this mixing region or chamber provided by cup **45** with a fluid dispenser, here being the atomizers **42** and **90**.

Regarding color choice, the color of fluid droplets **25** dispensed by the airbrush **30**, **30'** is determined by the ratios of the ink ejected as umnixed fluid **40**. Indeed, while the illustrated airbrush system **20** shows a separate manual color input selection device **70**, illustrated as a joystick device, in some embodiments it may be desirable to incorporate the color selection feature on the body **98**, here shown as an integrated color input selection device **100**, which may operate in the same fashion as described above for device **70**. In such an implementation, using the onboard color selection device **100**, the droplet generation controller **50** may be incorporated into the inkjet airbrush **30**, and also supported by body **98**, for instance, by supplying controller **50** as an integrated circuit, or more preferably as an application specific integrated circuit (ASIC) **102** or a field programmable gate array.

Indeed, by mounting the selection device **100** and controller **102** on or within the body **98**, and by incorporating the power source **24**, for instance in the form of batteries, within the body **98** a small hand-held unit or airbrush head may be formed, only requiring the attachment of a com-

pressed air source **22**. As a further enhancement, the compressed air source **22** may also be carried by the body **98**, for instance in the form of a small compressed air cartridge, similar to those used in BB guns and pellet rifles. Thus, with both the power source **24** and the compressed air source **22** onboard the body **98**, along with controller **102** and color selection toggle device **100**, a completely portable airbrush unit is formed.

Such a portable airbrush unit may include a digital input device, shown schematically as input device **104**, which may be coupled to a separate hand-held or other computing device. For instance, it may be particularly useful to have the digital input **104** be coupled to a device displaying a color selection chart, such as a Pantone book, colorimeter, or other color standard, where color selection may be made from a selection grid on the hand-held device, or digitally input in numeric or alpha numeric form. Alternatively, rather than input **104** being a digital input, the input **104** may also represent analog input, for instance using one or more rotary knobs to select the desired fluids to be dispensed by printhead **35**. In an alternate embodiment, the digital input device **104** may be a numeric rotary wheel input, allowing a person to dial in a numeric or alpha numeric code corresponding to a selected color on a standard color chart. Such a device would be particularly useful in a variety of different situations, for instance, to perform automotive touch up painting, where the color code for a vehicle is often printed on various name cards or placards affixed to the vehicle by the manufacturer. When the digital input **104** is coupled to a computer or other hand-held computing device, the exact manner of coupling the two may be accomplished in a variety of ways known to those skilled in the art, for instance, using an electrical cable, fiber optics, infrared technology, etc.

Regarding the color mixing surface of the mixing cup **45**, as the inks or other unmixed fluid **40** are ejected from printhead **35** they strike a mixing surface, the function of which is to quickly draw the inks through the funnel like structure of the mixing cup and to the airbrush for dispersion before the ink or other fluid dries. Thus, it may be undesirable for the inks or fluid to build up excessively on the mixing surface before entering the feed port of the internal atomizer **42**, or conduit **85** of the external atomizer **90**. For example, if one color entered the airbrush supply port at the bottom of the funnel-like mixing cup **45**, while another color builds up in an adjacent portion of the mixing surface then the color output of the airbrush would vary. A mixing surface, such as one constructed of a stainless steel or a plastic, which both worked well, allowed the inks to passively mix. During prototype testing, the inner surface of the mixing cup was varied in texture, to determine whether placing grooves in the cup **45** would enhance ink mixing and flow through the mixing cup. However, prototype testing indicated no significant advantage to a textured surface over a smooth mixing surface for the dye-based inks tested; however, in other implementations using other fluids, a grooved or textured interior surface may prove more satisfactory than a smooth surface.

A more specific use for this precision metering of a liquid, and more particularly for the mixture of two or more liquids, is illustrated in terms of an inkjet airbrush system **20**. Two examples of airbrush technology have been given, the internal atomizer **42** of FIG. **1**, and the external atomizer **90** of FIG. **3**. Further study by the inventor has revealed a variety of equivalent atomizers which may be substituted for atomizers **42** and **90** in creating the inkjet airbrushes, such as **30** and **30'** according to the concepts described herein.

There are a variety of general methods of atomization which may be substituted for atomizers **42** and **90**, and incorporated into an inkjet airbrush system. One of the first general methods of atomization is known as a twin-fluid atomizer. The internal and external airbrushes **42**, **90** fall within this twin-fluid atomizer category, with one fluid here being the inkjet ink, and the other the air from the compressed air source **22**. Another type of atomizer which may be suitable in some inkjet airbrush implementations is a rotary atomizer which atomizes without requiring an external air pump. Rather than a precise beam of fluid droplets **25**, rotary atomizers typically provide a spray pattern extending in 360°, which would be useful to paint the interior of pipes, storage tanks, and the like for instance. Another type of suitable atomizer is a pressure atomizer, which operates in a fashion similar to automotive fuel injectors and airless paint systems. With a pressurized atomizer, the fluid is under a high enough pressure, and the nozzle exit diameter is small enough, that the ejected fluid atomizes as it comes into contact with the air. Two other general methods of atomization include ultrasonic atomization, which typically is used in medical applications, and electrostatic atomization, typically used in paint sprayers. Several of these atomization mechanisms and spray methods are discussed in Arthur H. Lefebvre's book entitled "Atomization and Sprays," published in 1989 by Hemisphere Publishing Corporation, USA. A variety of different atomizers equivalent to atomizers **42** and **90** are described in Mr. Lefebvre's book, although it is apparent that other atomizers or other devices for generating a spray of fluid droplets **25** from liquid fluid **40** may also be substituted for atomizers **42** and **90**.

The color output of the airbrush **30**, **30'** may be determined by the amount of ink fired into the mixing chamber **45** from each of the color reservoirs within cartridge **32**. Preferably the compressed air source **22** is activated when the ink is firing into the mixing chamber **45** to draw the mixed ink out the chamber and into the airbrush nozzle **44** or opening **96** where the fluid is atomized and then ejected as droplets **25**. If the air source **22** is not activated during the ejection of the unmixed fluid **40**, then the ink may possibly overfill the mixing cup **45**, dirtying the interior of the airbrush body **98**. To prevent this situation, the controller **50**, **102** may coordinate operation of the air source **22** with the firing signal **38**, to assure this spillage situation is avoided. However, the spillage problem may occur any time when the ink **40** flowing into the mixing chamber **46** is greater than the amount of ink drawn out and expelled through nozzle **44** or opening **96**. Thus, balancing ink flow, air flow and nozzle geometry together provides an adequate solution to this spillage problem. For instance, in the prototype testing the geometry of nozzle **44** and the air flow through conduit **88** were adjusted to prevent the ink from overflowing the mixing chamber **45**.

The inkjet airbrush system **20**, whether using a separate operator input and controller section **28**, or onboard inputs **100**, **104** allows the user of airbrush **30**, **30'** to quickly choose and produce a desired color output **25**. Furthermore, the smaller the volume of space through which the ink travels from the printhead **35** to the exit of the spray nozzle **44** the faster color changes will be accomplished. The range of colors to choose from will be based on the contents of the fluid reservoirs **34** inside the cartridge **32**. Furthermore, there is a significant time savings in being able to dial in the desired color, whether using manual input devices **64**, **70**, **100**, **104** or the scanner **65** and computer **60**, rather than requiring colors to be manually mixed as in the past with conventional airbrushes. Color mapping from the ink sup-

plies within cartridge 32 to the airbrush output 44, 96 also allows for color selection from the computer screen 62. Once the colors are selected, the mapping section 52 determines what ratios of the base colors are required to produce the desired color. In this manner, digital, precise metering is achieved using the inkjet cartridge 32, leading to color reproduction which is enhanced over other earlier airbrushing techniques.

As mentioned above, a separate or non-artistic use for the airbrush system 20 may be to precisely meter two or more fluids for mixing, or to meter a single fluid. In the illustrated embodiments, inkjet inks have been used merely for convenience, and it is apparent that other fluids may also be mixed and ejected using the airbrush systems 30, 30'. For instance, various epoxy-type compounds having a fluid and a reagent that when mixed together form a time-sensitive mixture before becoming hardened may be suitably dispensed using the airbrush 30, 30'. In such a system, upon mixing the fluid and reagent hardening begins to occur immediately so there is a greater need to quickly apply fluid droplets 25 following ejection of the unmixed fluid 40 into cup 45. In some adhesive or bonding implementations, it may be desirable to include a third action, such as an ultra-violet curing step, to delay the mixture from hardening while traveling through the atomizer 42, 90.

Of course as a further modification, the inkjet airbrush 100 may be further modified to be an airbrush color mixer, for instance, by having the mixing cup 45 feed into a conventional airbrush paint reservoir. Such an implementation may be particularly useful where only small amounts of colorant are needed, such as when painting or applying polish to fingernails. Alternatively, the airbrush 42 may be designed with a small ink reservoir which is detachable from the mixing cup 30 for greater ease of handling with a more compact, lighter applicator. As a further alternative, the mixing cup 45 may stay attached to the atomizer 42 during use, with the cartridge 32 being detachable from the mixing cup 45.

Additionally, use of the precise color mixing provided by the inkjet airbrush system 20 advantageously allows two different inkjet airbrushes to accurately provide the same color output, for instance when two people are working on a project using two separate inkjet airbrushes. Moreover, use of a small mixing surface within cup 45 quickly brings different inks together and promotes passive mixing as the inks fall under the force of gravity down the conical walls of cup 45. Furthermore, in the mixing cup 45, liquid surface tension pulls the inks together and toward the exit port at the base of the mixing cup. Indeed, the liquid surface tension of the fluids in the mixing cup 45 in combination with the suction force provided by the atomizer 42 may actually overcome the force of gravity, allowing a user to paint an overhead object without any spillage. In this manner, minimal ink is wasted, and only the ink which is required to be placed on object 26 is mixed and used, thus providing consumers with a longer lasting cartridge 32. Furthermore, since the inkjet airbrush 30, 30' does not meter or control ink flow using a mechanical device, such as needle valves, mechanical levers, motors and the like, the inkjet airbrush 30, 30' is much less complex than earlier airbrush systems. Furthermore, as mentioned above since both textured and smooth surfaces for the mixing cup 45 were tested with no apparent difference in performance, a smooth surface is preferred because it is easier to clean than a textured surface. Finally, since fewer components of the inkjet airbrushes 30 and 90 are actually wet by the fluids being dispensed from printhead 35, the amount of clean-up required is minimized.

Thus, it is apparent that a variety of different modifications may be made to the fluid application system, and its use may be for applications other than inkjet ink mixing or painting, while still falling within the scope of the claims below.

I claim:

1. An airbrush mechanism, comprising:

a printhead which selectively ejects fluid in response to a firing signal;

a structure defining a mixing chamber which receives and mixes fluid ejected from the printhead; and

an atomizer which atomizes the mixed fluid from the mixing chamber and expels the atomized fluid.

2. An airbrush mechanism according to claim 1 further including a body which houses the printhead and the mixing chamber.

3. An airbrush mechanism according to claim 2 wherein the body houses the atomizer.

4. An airbrush mechanism according to claim 3 wherein the body houses a controller which generates the firing signal.

5. An airbrush mechanism according to claim 4 wherein the controller generates the firing signal in response to an operator input device.

6. An airbrush mechanism according to claim 5 wherein the body houses the operator input device.

7. An airbrush mechanism according to claim 4 wherein the controller generates the firing signal in response to an input generated by an external device.

8. An airbrush mechanism according to claim 7 wherein the body houses an interface to receive the input generated by the external device.

9. An airbrush mechanism according to claim 4 wherein the body houses a power source which powers the controller to generate the firing signal.

10. An airbrush mechanism according to claim 9 wherein the body houses a pressurized air source which supplies the atomizer.

11. An airbrush mechanism according to claim 9 wherein the body has an interface which receives pressurized air from an external source to supply the atomizer.

12. An airbrush mechanism according to claim 4 wherein the body has an interface which receives power from an external source to power the controller to generate the firing signal.

13. An airbrush mechanism according to claim 2 further including a fluid reservoir housed by the body.

14. An airbrush mechanism according to claim 2 further including plural reservoirs housed by the body, with each of said plural reservoir containing a different fluid composition.

15. An airbrush mechanism according to claim 14 wherein one of said plural ink reservoirs contains a first fluid, and another of said plural reservoirs contains a second fluid which, when mixed together with the first fluid in the mixing chamber forms a time-sensitive mixture.

16. An airbrush mechanism according to claim 14 wherein a first of said plural ink reservoir contains a first colorant, a second of said plural reservoirs contains a second colorant, and a third of said plural reservoirs contains a third colorant.

17. An airbrush mechanism according to claim 16 wherein the first colorant comprises cyan, the second colorant comprises magenta, and the third colorant comprises yellow.

18. An airbrush mechanism according to claim 17 wherein a fourth of said plural ink reservoirs contains a fourth colorant comprising black.

19. An airbrush mechanism according to claim 14 wherein each of the plural reservoirs are contained within an inkjet cartridge which supports the printhead, and wherein the cartridge is housed by the body.

20. An airbrush mechanism according to claim 1 wherein the atomizer comprises an external atomizer.

21. An airbrush mechanism according to claim 1 wherein the atomizer comprises an internal atomizer.

22. An airbrush mechanism according to claim 21 wherein fluid flow through the atomizer is controlled by an amount of fluid ejected by the printhead.

23. An airbrush mechanism according to claim 1 wherein the printhead comprises a thermal inkjet printhead.

24. An airbrush mechanism according to claim 1 wherein the printhead comprises a piezo-electric inkjet printhead.

25. An airbrush mechanism according to claim 1 wherein a controller generates the firing signal.

26. An airbrush mechanism according to claim 25 further including:

a body which houses the inkjet printhead and the mixing chamber;

wherein the controller comprises an external controller; and

wherein the body has an interface which receives the firing signal from the external controller.

27. An airbrush mechanism according to claim 26 wherein the body houses the atomizer.

28. An airbrush mechanism according to claim 25 wherein the controller generates the firing signal in response to an operator input.

29. An airbrush mechanism according to claim 28 wherein the operator input comprises a selection from a color chart.

30. An airbrush mechanism according to claim 29 wherein the operator input comprises code representative of said selection from the color chart.

31. An airbrush mechanism according to claim 25 wherein the controller generates the firing signal in response to a computer-generated input.

32. An airbrush mechanism according to claim 31 wherein the computer-generated input is generated in response to an input received from a scanner.

33. An airbrush mechanism according to claim 31 wherein the computer-generated input is generated in response to an input received from an internet source.

34. An airbrush mechanism according to claim 31 wherein the computer-generated input is generated in response to an input received from an operator input to a computing device which generates said computer-generated input.

35. An airbrush mechanism according to claim 25 wherein the controller includes a color mapping portion which generates color signals.

36. An airbrush mechanism according to claim 35 wherein the controller includes firing signal generator portion which generates the firing signals in response to the color signals generated by the color mapping portion.

37. An airbrush mechanism according to claim 1 wherein the printhead is coupled to the mixing chamber when ejecting the fluid.

38. An airbrush mechanism according to claim 37 wherein the atomizer is fluidically coupled to the mixing chamber when expelling the atomized fluid.

39. An airbrush mechanism according to claim 1 wherein said structure comprises a conical-shaped funnel having an interior surface which defines the mixing chamber.

40. An airbrush mechanism according to claim 39 wherein said interior surface comprises a smooth surface.

41. An airbrush mechanism according to claim 39 wherein said interior surface comprises a textured surface.

42. An airbrush mechanism according to claim 1 further including a body which houses the mixing chamber and the atomizer.

43. An airbrush mechanism according to claim 42 wherein the body houses a power source which powers the controller to generate the firing signal.

44. An airbrush mechanism according to claim 42 wherein the body houses a pressurized air source which supplies the atomizer.

45. A method of applying a fluid on an object, comprising:

generating a firing signal;

ejecting fluid from a fluid ejection head in response to the firing signal;

mixing the ejected fluid;

atomizing the mixed fluid; and

propelling the atomized fluid onto the object.

46. A method according to claim 45 further comprising containing the printhead and the mixing chamber within a body.

47. A method according to claim 45 further comprising containing the mixing chamber and the atomizer within a body.

48. A method according to claim 45 further comprising containing the printhead, the mixing chamber, and the atomizer within a body.

49. A method according to claim 45 wherein generating comprises generating the firing signal in response to an operator input device.

50. A method according to claim 49 further comprising containing the printhead within a body which houses the operator input device.

51. A method according to claim 45 wherein generating comprises generating the firing signal in response to an input generated by an external device.

52. A method according to claim 45 further comprising:

receiving power from an external source; and

wherein the generating comprises generating the firing signal using the power received from the external source.

53. A method according to claim 45 further comprising:

receiving pressurized air from an external source; and

wherein atomizing comprises atomizing the mixed fluid using pressurized air from the external source.

54. A method according to claim 45 wherein atomizing comprises using an external atomizer.

55. A method according to claim 45 wherein atomizing comprises using an internal atomizer.

56. A method according to claim 45 wherein ejecting comprises using a thermal inkjet printhead.

57. A method according to claim 45 wherein ejecting comprises using a piezo-electric inkjet printhead.

58. A method according to claim 45 wherein generating comprises generating the firing signal in response to a code representative of a selection from a color chart.

59. A method according to claim 45 wherein generating comprises generating the firing signal in response to a computer-generated input.

60. A method according to claim 59 further comprising generating the computer-generated input in response to an input received from a scanner.

61. A method according to claim 59 further comprising generating the computer-generated input in response to an input received from an internet source.

62. A method according to claim **59** further comprising generating the computer-generated input in response to an input received from an operator input to a computing device which generates said computer-generated input.

63. A method according to claim **45** further comprising color mapping an input prior to generating the firing signal.

64. A method according to claim **45** further comprising containing the printhead within a body, and containing a fluid reservoir in the body.

65. A method according to claim **45** further comprising containing the printhead within a body, containing plural reservoirs in the body, and storing different fluid compositions in each of said plural reservoirs.

66. A method according to claim **65** wherein:

one of said plural ink reservoirs contains a first fluid;

another of said plural reservoirs contains a second fluid;

ejecting comprises ejecting the first and second fluids; and

mixing comprises mixing the first fluid and the second fluid together.

67. A method according to claim **66** further comprising, following the propelling step, chemically reacting the first fluid with the second fluid.

68. A method according to claim **65** wherein a first of said plural ink reservoirs contains a first colorant, a second of said plural reservoirs contains a second colorant, and a third of said plural reservoirs contains a third colorant.

69. A method according to claim **68** wherein the first colorant comprises cyan, the second colorant comprises magenta, and the third colorant comprises yellow.

70. A method according to claim **69** wherein a fourth of said plural ink reservoirs contains a fourth colorant comprising black.

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